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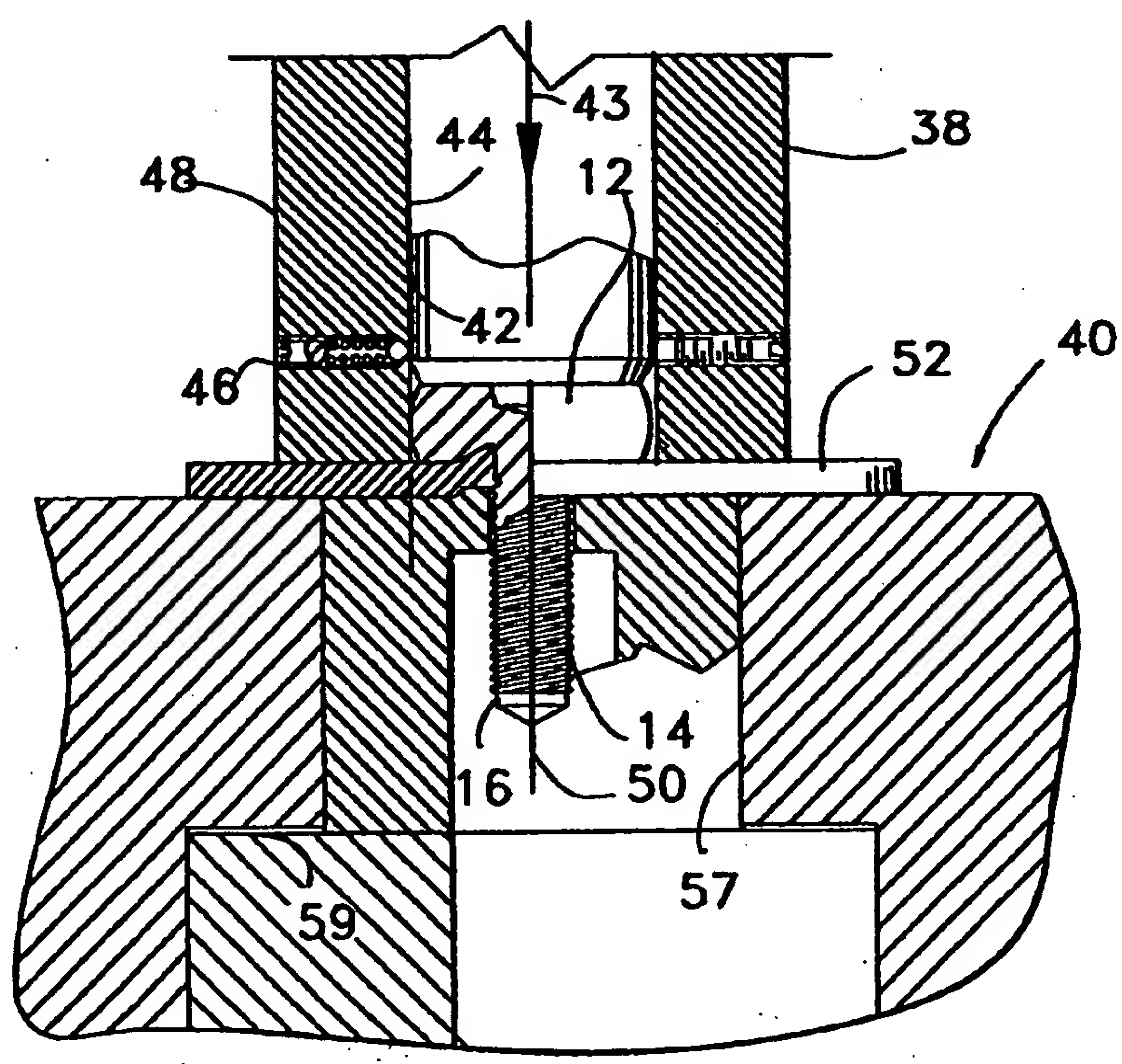
(57) Abstract

The present invention relates to a fastener (10) which comprises a shaft portion (16) and an integral head portion (12), an assembly comprising a sheet metal part (52) and the fastener (10), a method for manufacturing the assembly, and a die (54) for manufacturing the assembly. The underside (18) of the head portion (12) adjacent the shaft portion (16) includes a plurality of spaced shallow pockets (20) which entrap the sheet metal. The shaft portion (16) includes at least one depression (28). The die (54) includes a central opening (60) which receives the shaft portion (16), and a crown area (64) surrounding the opening, which crown area (64) includes peaks (72) and valleys (74) which deform the sheet metal part (52) into the pockets (20) in the head portion (12) and radially inwardly into the depression on the shaft portion (16) thereby forming a fastener (10) and sheet metal part (52) assembly.



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RIVETABLE ELEMENT, ASSEMBLY, METHOD OF ASSEMBLY AND RIVETING DIE

FIELD OF THE INVENTION

This invention relates to self-riveting elements or fasteners, such as screws, bolts, nuts and the like, wherein the rivetable element includes a shaft or barrel portion and an integral head portion having a riveting portion on the underside of the head portion, adjacent the shaft or barrel portion. The field of this invention also relates to riveting dies having a central opening which receives the shaft or barrel portion of the riveting element and a riveting portion adjacent the opening which deforms the sheet metal part or panel to which the riveting element is attached into the riveting portion of the fastener head. Finally, the field of this invention relates to methods of attaching riveting elements of the type described to a sheet metal part or plastically deformable panel.

RELATED APPLICATIONS

This application claims priority to German patent application P 44 10 475.8 filed March 25, 1994.

BACKGROUND OF THE INVENTION

As described, the present invention relates to improved self-riveting elements or fasteners having a shaft or barrel portion and an integral head portion which may be permanently affixed to a sheet metal part or panel by riveting. Elements of this type are previously known, wherein the shaft is generally threaded and introduced in a pre-formed hole in the sheet metal part. The head portion then bears on one side of the metal part. The sheet metal part or panel is then shaped in a setting operation, such that the panel molds physically into a small groove in the shaft of the element, directly adjacent to the bearing

surface on the underside of the head portion, thereby securing the element in a sheet metal part or panel. The underside of the head, adjacent the shaft, may include radial ribs and the panel is deformed over the ribs during installation, preventing relative rotation of the elements on the sheet metal panel. Such assemblies are frequently used in industrial production by the automotive and appliance industries to fasten another component to the assembly, which may consist of a second sheet metal part and fastener, such as a nut. The contact surface of the head portion is thus located on one side of the first panel, opposite the second fastening element, such that the sheet metal part is stressed by compression between the fasteners.

In practice, however, the previously known self-riveting elements of this type were not securely attached to the metal part, such that the element commonly loosened in shipping or storage before assembly, particularly where the sheet metal part is relatively thin as now used by the automotive and appliance industries. It is not uncommon for the riveting element to become lost or assume an orientation in the panel which is unacceptable for further processing of the sheet metal part, as described above. The loosening of the prior self-riveting elements of this type also sometimes resulted in inefficiency of the intended anti-rotation means, such that the element will rotate as the nut is assembled on the shaft portion, before the nut is tightened on the bolt. These difficulties are a particular problem in automotive body construction and other applications where the head portion of the riveting elements are located in an enclosed cavity following installation, which is no longer accessible for repair. If the fastening element freely rotates in the panel or is lost under these conditions, the object being manufactured, such as an automobile, can no longer be finished in regular production, but must be repaired at substantial expense. Obviously, these problems should be avoided, if possible.

Another problem, particularly with attaching a riveting fastener to thin sheet metal panels results from the fact that the anti-rotation ribs must have a certain height; that is, the height of the ribs from the contact surface on the underside of the head portion must be sufficient to prevent rotation. Where the sheet metal part is relatively thin, the ribs dent the panel to a degree such that the full strength of the sheet metal part is no longer available, which may lead to further problems.

Another disadvantage of self-riveting male fastener elements of this type is that the small groove in the shaft portion which receives the panel material to prevent pull-out is difficult to make and thus unnecessarily increases the cost of the fastener. Further, this radial groove results in an undesirable reduction in the strength of the bolt or screw fastener, including its fatigue properties, resulting from the sharp edges and reduction of the cross-sectional area of the shaft portion of the element. Further, because of the groove dimensions, the element may also be insufficiently secured to the sheet metal part, aggravating the tendency of the element to loosen in the sheet metal part or drop out, as described above.

Thus, a primary object of the present invention is to provide a self-riveting element of this type which can be manufactured and fixed to the sheet metal panel at a relatively low cost and wherein the risk of loosening or loss of the element out of the sheet metal part is reduced and preferably precluded. Another object is to provide a joint between the self-riveting element and panel which is as strong as possible and a self-riveting element or fastener which is suitable for attachment to thin sheet metal parts, including nonferrous sheet metal parts, such as aluminum or its alloys.

SUMMARY OF THE INVENTION

The self-riveting element or fastener of this invention includes several inventive features or elements which, in combination, result in an improved element and fastener and panel assembly, and reduces the cost of the assembly. As will be understood, however, the inventive features of this invention may also be used separately, particularly where the function of a particular feature is desired or the function of another feature is not desired. As described above, the self-riveting element or fastener of this invention includes a shaft or barrel portion and an integral head portion which extends generally transverse to the longitudinal axis of the shaft or barrel portion and which provides an annular contact surface on the underside of the head portion adjacent the shaft or barrel portion. In the preferred embodiment, the contact surface includes a plurality of concave pockets or closed fields which are bounded by ribs extending outwardly away from the shaft portion. In the most preferred embodiment, the pockets include a bottom wall which extends radially inwardly toward the shaft portion and the ribs between the pockets extend longitudinally along the shaft portion. In the most preferred embodiment, the shaft portion further includes at least one radial depression or groove which is spaced from the plane of the contact surface of the head portion, preferably a distance equal to approximately the thickness of the sheet metal part or panel to which the riveting element is attached. This depression or groove most preferably extends spirally around the shaft portion and may be the groove of the first thread where the shaft or barrel portion is threaded.

This design makes it possible in riveting the element or fastener to the sheet metal part or panel to plastically deform the material of the sheet metal part by a suitable die arranged concentrically to the shaft into the concave, peripherally closed fields or pockets in the underside of the head portion and radially into the depression or groove in the shaft

portion with essentially no thinning of the sheet metal part. Further, the self-riveting element or fastener of this invention prevents rotation of the fastener in the panel without weakening of the sheet metal part, thus avoiding the problems associated with the projecting radial ribs on conventional self-riveting elements of this type. Further, because the ribs between the concave pockets extend longitudinally along the shaft portion, the anti-rotation is achieved not only through the material driven into the concave fields, but also by the positive connection between the longitudinal ribs on the shaft portion and the sheet metal part. As a result, the torque resistance of the fastener in the panel is considerably improved. In attaching the element to the panel, the sheet metal part is not unnecessarily reduced in thickness and the depression or groove in the shaft portion may be located further away from the underside of the contact surface of the head than would be possible with the radial groove according to the prior art, such that the depression can be more easily formed. Further, the shape of the depression or groove can be formed more cleanly than where the groove is located immediately adjacent the head as in the prior art, insuring that the sheet metal will be more fully deformed into the depression, thereby generating an improved resistance to push-off of the fastener and loss of the element from the sheet metal part, as described above.

Another advantage of the self-riveting fastener element of this invention is the location of the longitudinal ribs and the radial depression or groove on an enlarged portion of the shaft adjacent the head. Owing to this design, the self-riveting element is weakened less by the depression, allowing a more full utilization of the rated strength of the fastener element and an improvement of the fatigue properties of the element. Further, the torque resistance of the element in the panel is also improved. Of special importance, however, is that the flow performance of the sheet metal part material can be improved in the attachment of the

fastener to the panel. Preferably, the preformed or prefabricated hole in the sheet metal part has a diameter which enables the insertion of the shaft portion without damage. The large diameter portion of the shaft portion preferably has a diameter which is slightly greater than the opening or hole in the panel, such that the diameter of the hole is enlarged during installation of the self-riveting element in the panel, which provides additional material which can be driven into the concave, peripherally closed fields or pockets in the head and into the radial depression in the shaft portion. It is also possible to conically deform the sheet metal part adjacent the hole in accordance with the disclosure of U.S. co-pending application Serial No. 343,724 filed November 22, 1994, the disclosure of which is incorporated herein by reference. The shaft or barrel portion of the self-riveting element is then received through the conical opening, through the apex of the conical-shaped depression and the panel is then pressed flat by driving the head portion against the panel, thereby making additional material available for forming a tight joint between the element and the sheet metal part.

The spiral depression or groove in the shaft portion can be formed by a threaded groove, namely a continuation of a threaded portion on the shaft of the self-riveting element. In this manner, the depression is made in the same operation as when the thread is formed or cut in the shaft portion. This leads to a considerable cost saving in the manufacture of the self-riveting fastener element and also leads to a clean spiral depression. If the longitudinal ribs are formed on the shaft portion, adjacent the head, to the smaller diameter portion of the shaft during the thread rolling operation, which is preferred, the depression or groove can be readily deformed during the thread rolling operation, such that all threads end in the depression. Alternatively, however, it is possible for the ribs to be formed after the thread rolling operation in a separate step, for example, also in a thread rolling operation. In this case, the depression would be divided into several sections by the ribs. Further, the

relieved portion between the ribs extending along the shaft should not extend into the depression to avoid interference with the deformation of the panel into the depression. An exception would apply where the self-riveting elements are used for attachment of an electrical terminal. In that case, the ribs could produce a desirable kerfing effect in the opening of the terminal, which could be beneficial to creating a good electrical contact.

The spiral depression may represent one or two threads and may also be in the form of thread sections, especially where the depression is fashioned as a multiple-start threading, which would be useful for the rivetable element of this invention. The spiral depression or groove has yet another advantage as compared to a circular radial groove. Following installation after extended use, additional torque may be required to remove the nut from the shank portion of the stud because of contamination or corrosion. Such elevated torque, however, will result in forcing the riveting element against the sheet metal part due to the spiral shape of the depression, such that increased torque resistance is provided. Although a spiral groove is preferred for the reasons set forth above, it is also possible to utilize a circular groove or depression wherein the pitch of the depression is zero degrees. This form may be preferred wherein the shaft portion of the self-riveting element is unthreaded, such as an axle journal. The depression or groove should, however, be spaced from the underside of the head, as described above.

As will be understood, the area of the enclosed fields or pockets relative to the contact area, may be selected for optimal torque resistance. Thus, it is possible to use the self-riveting element of this invention in conjunction with softer metals, including aluminum alloy panels, which are being used increasingly in automotive applications. In such applications, the material of the self-riveting element may be selected to avoid galvanic corrosion, wherein the self-riveting element may be formed of an aluminum alloy.

As described, the die member utilized for assembly of the self-riveting element of this invention includes a bore which receives the shank or barrel portion of the fastener and the opening is preferably crowned to deform panel metal into the confined fields or pockets in the head portion of the element. As will be understood, the bottom surface of the groove in the underside of the head portion will depend upon the shape of the die used. Further, the self-riveting element may be a male fastening element, such as a screw or bolt, or a female element, such as a nut, wherein the shaft portion is replaced by an annular barrel portion.

The method of this invention thus includes forming a hole in the sheet metal part by punching, drilling or the like; inserting the shaft or barrel portion of the self-riveting element through the hole in the sheet metal part or panel; then plastically deforming the sheet metal part material in the vicinity of the panel hole to at least partially fill the pockets in the underside of the head and radially inwardly into the groove or depression in the shank or barrel portion of the self-fastening element.

Other advantages and meritorious features will be more fully understood from the following description of the preferred embodiments, the appended claims and the drawings, a brief description of which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side elevation of one embodiment of the self-riveting element of this invention, which is partially cross-sectioned for clarity;

Figure 2 is an end view of the self-riveting element shown in Figure 1;

Figure 3 is an enlarged cross-sectional partial view of the self-riveting fastening element shown in Figure 1;

Figure 4 is a partial cross-sectional end view of Figure 3 in the direction of view arrows 4-4;

Figure 5 is a schematic illustration of an installation apparatus or setting head of this invention illustrating the first step of the method of installation of this invention;

Figure 6 is a partial cross-sectional view similar to Figure 5 following installation of the self-riveting fastening element shown in Figure 5;

Figure 7 is a detailed partial cross-sectional side view of the riveting die shown in Figures 5 and 6;

Figure 8 is a side partially cross-sectioned view of the self-riveting fastening element shown in Figures 1 to 4 installed in a sheet metal part;

Figure 9 is an enlarged partial cross-section view of Figure 8 in the area indicated by reference 9;

Figure 10 is a side partially cross-sectioned view similar to Figure 1 of a second embodiment of the self-riveting fastening element shown in Figure 1, wherein the shank portion of the riveting element is unthreaded;

Figure 11 is an end view of the fastening element shown in Figure 10;

Figure 12 is a partial cross-sectional view of the riveting element shown in Figure 10;

Figure 13 is an enlarged partially cross-sectional view of Figure 12;

Figure 14 is a side partially cross-sectioned view of another embodiment of the self-riveting element of this invention in the form of a female element;

Figure 15 is an end view of the self-riveting element shown in Figure 14;

Figure 16 is an enlarged partially cross-sectioned side view of the fastening element shown in Figure 14;

Figure 17 is an end partially cross-sectioned view of Figure 16 in the direction of view arrows 17-17;

Figure 18 is a partially cross-sectioned side view of another embodiment of the self-riveting element of this invention in the form of a threaded female fastening element installed in a panel; and

Figure 19 is an enlarged view of the fastening element shown in Figure 18.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a side elevation of one embodiment of the rivetable element 10 of the invention in the form of a threaded bolt having a head portion 12 and a shaft portion 16 which is externally threaded at 14. As shown in further detail in Figures 2, 3 and 4, the underside 18 of the head portion 12 has a concave contact surface including peripherally closed fields or pockets 20 which are partly bounded by ribs 22 which extend radially outwardly from the shaft portion 16 as shown in Figures 2 and 4 and which are continuous with rib portions 24 which extend axially along the shaft portion 16 as shown at 24 in Figure 3. As shown, the ribs 24 extend from the head portion to 26 to depression or groove 28 which in the disclosed embodiment is the first spiral groove of the threaded portion 14 of the shaft.

As shown in Figures 2 and 4, the closed fields or pockets 20 are bounded on their radial outer side by surrounding annular peripheral surface 30 of the head, with the ribs 22 defining the radial surface which is continuous with the annular surface 30. The radial inside of the pockets 20 are defined by a cylindrical peripheral surface 32 of the shaft portion. As shown in Figure 3, the rib portions 22 extend obliquely to the plane 31 defined by the underside of the head portion 12 or backed-off from this plane (31) such that the ribs do not protrude from this backed-off plane adjacent the shaft portion of the self-riveting element.

It will be understood, however, that the rib portions 22 may be located in the same plane 31 as the peripheral surface 30. The peripheral surface 30, as well as the surfaces adjacent the shaft 22, form the actual contact surface of the head portion 12. In this embodiment, the closed fields or pockets 20 are generally quadratic or rectangular which, in practice, is a favorable shape. It will be understood, however, that the pockets may be shaped differently within the purview of the present invention. With the embodiment disclosed in Figures 2 and 4, the rib portions 22 in the contact area of the underside 18 of the head portion 20 expand radially outwardly as shown in Figures 2 and 4. Further, the rib portions 22 extend continuously and without interruption into the outer peripheral surface 30 of the head portion. In the disclosed embodiment, there are eight rib portions 22, with the preferred number of rib portions ranging from between six and eight.

As evident from Figures 1 and 3, the pockets or closed fields 20 have their greatest depth measured axially in the direction of axial line 35 (in Figure 1) adjacent the shaft portion 16. The contact surface on the underside 18 of the head 12 comprises primarily the rib portions 22 and the peripheral outer surface 30. The bottom surfaces of the pockets 20 can be used as a contact surface through deformation of the sheet metal part into the closed fields or pockets. The contact surface is thus relatively large, such that the rivetable element 10 may be used with relatively soft sheet metal parts without concern that a critical surface pressure will result. In the most preferred embodiment, the bottom surfaces of the closed fields are located on a conical shell surface with an inscribed angle of preferably between about 130° to 140°. This taper angle is referred to in Figure 3 as angle α. Thus, the rivetable element 10 of the embodiment shown in Figures 1 to 3 features a centering depression which assures a high-quality, valuable guidance of the element. A conical pilot point 36 at the end of the shaft portion 16 not only provides a female fastener or nut received

on the shaft portion with a lead-in, but also guides the self-riveting element in the setting head as it is inserted into the sheet metal part, as described below.

The setting or assembly operation is schematically illustrated in Figures 5 and 6. The installation tool 40 shown in Figure 5 includes a setting or installation head 38 having a press joining punch 42 movable in the direction of arrow 43. Arrow 42 indicates the feed direction of the self-riveting element 10 in the installation head. The self-riveting elements 10 are fed individually to the installation head 38. The self-riveting element 10 shown in Figure 5 proceeds under gravity, compressed air or the joining punch 42 through bore 44 of the installation head until the head portion 12 of the element contacts the ball 48, which is resiliently biased into the bore 44 by spring 46. In practice, three spring biased balls are provided arranged at intervals of 120° around the longitudinal axis 50 of the installation head 38. In the station of Figure 5, the prepunched sheet metal part 52 into which the element 10 is to be installed is retained between the installation head 38 and a riveting die member 54 of a lower tool 56. The shaft portion 16 of the self-riveting element 10 is provided with a threaded portion 14 which is partially received through the preformed hole in the sheet metal part and through a coaxially aligned cylindrical centering hole 60 in the riveting die 54. The riveting die 54 is releasably retained within a bore 57 of the lower tool 56 and bears against a bolster 59 on a lower press plate 61.

In the subsequent station of the setting operation, the press/joining punch 42 provided in the installation head 38 moves further downwardly, forcing the head portion of the element past the spring loaded balls 48. During this motion, the surrounding crown area 64 shown in Figure 7 of the riveting die is forced into the material of the sheet metal part deforming the sheet metal into the V-shaped groove 23 which includes the enclosed fields or pockets 20 and into the recess 28, thereby creating a secure, riveted joint between the riveting

element 10 and the sheet metal part 52, forming a secure assembly. The preferred embodiment of the riveting die 54 includes a crown area 64 which surrounds the hole 58 as shown in Figure 7. That is, the annular crown-shaped area of the riveting die defines a wavy end face with peaks 72 and valleys 74 extending in axial direction. In the operation, the relief peaks 72 deform and drive the material of the sheet metal part into the concave fields or pockets 20 in the underside 18 of the head portion of the element, while the valleys 74 make contact with the sheet metal part opposite the ribs 22 which extend radially outwardly, such that there is no pronounced thinning of the sheet metal part in the area of the ribs.

Because the sheet metal material is deformed between the riveting die and the underside of the head portion 12 of the element 10, the sheet metal material is also forced to flow into depression 28, thereby forming the desirable positive joint. Unexpectedly, it is not necessary to angularly align the element 10 on the peaks and valleys of the crown portion 64 because the element will rotate to assume a position in which the peaks 72 of the riveting die 54 are aligned with the concave fields or pockets 20. That is, the necessary alignment takes place through a slight automatic twist of the element during the installation operation.

A groove 80 is formed in the sheet metal part 52 by the crowned area 64 of the die member 54 as shown in Figures 8 and 9. This groove 80 may be interrupted, but extends around the shaft portion 16 of the self-riveting fastener on the side of 71 of the sheet metal part away from the head 12 of the fastener as shown in Figures 8 and 9. As will be understood, this groove 80 features a wavy bottom surface; however, the peaks of the wavy bottom surface should not protrude beyond the underside 71 of the sheet metal part in order to provide a clean seating of the nut or other object to be attached to the sheet metal part. An exception is where the object to be attached to the sheet metal part is an electrical terminal. In such case, the peak areas of the wavy bottom surface may protrude beyond the

underside 71 of the sheet metal part to provide a greater contact surface pressure on the terminal, providing a better electrical contact.

As will be understood, the self-riveting element of this invention may be a female fastener, such as a nut, or any other type of element which may be permanently attached to a sheet metal part, such as a metal panel used by the automotive and appliance industries. Figures 10 through 13, for example, illustrate an element 110 in the form of an axle journal. Because of the similarities of the element 110 with the self-riveting element 110 discussed hereinabove, similar reference numbers are used for the element 110 shown in Figures 11 and 12 and for all further embodiments described hereinbelow to avoid unnecessary duplication of description.

The differences between the axle journal 110 shown in Figures 10 through 13 and the dread bolt 10 are not very significant. Major differences are found in two areas. First, the shaft portion 116 of element 110 includes a cylindrical bearing surface 115, such that the shaft portion is not threaded. It will be understood, however, that the cylindrical bearing surface 115 may include a threaded section in order to tighten the sheet metal part with an appropriate nut or nut and washer arrangement between the head portion 112 and the nut or to secure an interior bushing of the object mounted on the axle journal against axial shifting in a longitudinal direction of the element.

Second, the groove 128 into which the sheet metal is deformed is an annular groove, rather than a spiral groove thread as groove 28 in Figure 3. The annular or circular groove 128 may thus be considered as a spiral groove with an angle of inclination equal to zero degrees. From Figure 12, it can be seen that this surrounding groove 128 is arranged approximately an equal distance to the sheet metal thickness from the contact surface 118 of the head 112 and that this distance is substantially greater than similar grooves provided in

the fastening elements disclosed in the prior art. It is thus easier to form the groove or depression in the shaft portion than where the groove is located immediately adjacent the head portion 112 as disclosed in the prior art. As described above, however, the groove 128 may be formed as a thread groove as shown at 28 in Figures 1 through 4. The groove 128 is formed in this embodiment in the bearing area of the shaft portion adjacent the head portion 112 which may be possible and preferred with the element shown in Figures 1 to 9. The positive joint between the element 110 and a sheet metal part accomplished exactly as described above in regard to Figures 8 and 10 with the threaded bolt 10.

The riveting element of this invention may also be in the form of a female element, such as the bearing bushing 210 shown in Figures 14 to 17 and the nut fastener 310 shown in Figures 18 and 19. The bearing bushing 210 shown in Figures 14 to 16 includes an axial through-bore 282 having a cylindrical center portion 282 which provides the bearing surface. In Figure 14, the upper portion of the bore 282 includes a centering hole 234 having a diameter somewhat larger than the bearing surface 282. The lower portion of the bore 284 includes an enlarged diameter portion 286 which serves to prevent deformation of the shaft portion of the nut due to plastic deformation of the sheet metal part into the fields or pockets 220 and the depression 228, which would result in constriction of the cylindrical bore 282, which would prevent the bearing part from being inserted in the element 210. In this embodiment, the head portion is a radial flange 212 and the shaft portion is an annular barrel portion 216. As set forth above, similar elements are numbered as described above in regard to Figures 1 to 13.

As shown in Figures 18 and 19, the riveting element 310 may be provided with an internal thread 388, such that the element 310 may be used as a nut fastener following installation in a metal part 352, as shown. This embodiment is very similar to the bearing

bushing 210 shown in Figures 14 to 17, except that the bore 388 is threaded. The head portion 312 is in the form of a radial flange portion and the shaft portion 316 is a tubular or annular barrel portion which includes a radial depression. It will be understood, however, that the annular barrel portion may also be extended and externally threaded. The threaded bore 388 may then receive a threaded screw (not shown) to attach a further object or element to the metal part 352. When using a female element 310 according to Figures 18 and 19, a cup-shaped depression 392 may be preferred in the sheet metal part 352, which allows flush mounting of an object on the underside 371 of the sheet metal part. This cup-shaped depression 392 may be created in the sheet metal part 352 either by a preceding operation as the sheet metal part is being punched or by a special shaping end face of the riveting die shown in Figures 5 and 6 as will be understood by those skilled in the art. The female riveting elements shown in Figures 14 to 19 may be attached to a metal part by the installation apparatus shown in Figures 5 and 6, as described above.

As will now be understood, the self-riveting element and method of installation of this invention may be utilized for a broad range of applications, including male and female elements, fasteners and the like. Further, the several improvements disclosed herein may be used in combination or separately to produce an improved element and fastener assembly. For example, the peripherally closed fields or pockets (20, 120, etc.) provide anti-rotation means for the fastener assembly. Thus, the pockets may not be utilized in a fastener assembly where anti-rotation means is not desired. The method of this invention may then include forming a hole through the panel having a diameter greater than the stud or barrel portion of the elements, supporting the panel on a die assembly having an opening coaxially aligned with the panel hole configured to receive the stud or barrel portion of the fastening element, but having a diameter less than the head or flange portion of the bearing surface,

wherein the die member includes a projecting annular lip coaxially aligned with the groove in the riveting element. In the preferred embodiment, the groove 23 is generally V-shaped and extends into the flange or head portion of the element adjacent the barrel or stud portion, as shown in Figure 3. The method then includes inserting the stud or barrel portion of the element through the panel hole into the die member opening, receiving the head or flange portion bearing surface against the panel, adjacent the panel opening. The method then includes driving the bearing surface of the element against the panel, causing the die member annular lip to substantially simultaneously deform the panel metal into the axial groove and radially into the radial groove of the element. In the most preferred embodiment, the radial groove is the first thread of a threaded portion of the fastener, such as shown in Figure 3; however, the groove may be annular as shown at 128 in Figure 10. The element and metal part or panel assembly thus includes a self-riveting element, as disclosed, and a metal part or panel, wherein the stud or barrel portion of the element is received through an opening or hole in the metal part or panel and the panel or metal part is deformed into both the V-shaped annular groove which surrounds the stud or barrel portion and into the radial groove in the stud or barrel portion. In the most preferred embodiment, the panel portion is further and simultaneously deformed into the circumferentially spaced confined fields or pockets, forming a very secure assembly which prevents pull-out and rotation of the self-riveting element in the panel. In the most preferred embodiment, the self-riveting element is a fastener which may be utilized to attach a second element to the panel. In the embodiment 10 disclosed in Figures 1 to 4, the fastening element is a male fastening element, such as a screw or bolt 10. In the embodiment 110 shown in Figures 10 to 13, the fastening element 110 is an axle journal, wherein the cylindrical stud portion 15 receives a female member having a cylindrical bore, which is attached to the stud portion of the fastening element. In

the embodiment 210 disclosed in Figures 14 to 17, the fastening element 210 is a bearing bush which receives a male element having a cylindrical surface which is received in the bore 82 of the bushing. Finally, in the embodiment 310 shown in Figures 17 and 18, the fastening element is a nut fastener, which receives a screw or bolt for attachment of an element to the panel. Having described the preferred embodiments of the riveting element, method of attachment and assembly of this invention, it will be understood by those skilled in the art that various modifications may be made to the disclosed embodiments within the purview of the appended claims, which follow.

CLAIMS

1. A method of attaching a fastening element to a plastically deformable metal panel, said fastening element including radial flange portion and a generally cylindrical axially projecting fastener portion, said flange portion including an annular bearing surface generally surrounding said fastener portion and said bearing surface including a generally annular groove extending axially into said flange portion adjacent to and surrounding said fastener portion, said fastener portion having a radial groove spaced axially from the plane of said bearing surface of said flange portion, said method comprising the following steps:

forming a generally cylindrical hole through said panel having a diameter greater than said fastener portion of said fastening element, but less than said bearing surface;

supporting said panel on a die assembly including a die member having an opening coaxially aligned with said panel hole configured to receive said fastener portion of said fastening element having a diameter less than said flange portion bearing surface, said die member including a projecting annular lip generally coaxially aligned with said axial groove of said fastening element;

inserting said fastener portion of said fastening element through said panel hole into said die member opening and receiving said flange portion bearing surface against said panel adjacent said panel opening;

then driving said bearing surface of said fastening element flange portion against said panel, said die member annular lip then substantially simultaneously deforming said metal panel axially into said groove in said flange portion and radially into said radial groove of said fastener portion to form a secure mechanical interlock between said fastening element and said metal panel.

2. The method of attaching a fastening element to a metal panel as defined in claim 1, characterized in that said fastening element is a male threaded member, said method including externally threading said fastener portion of said fastening element to adjacent said axial groove of said flange portion, a thread adjacent said axial groove then defining said radial groove, said method further including deforming said panel radially into said thread adjacent said groove in said flange portion.

3. The method of attaching a fastening element to a metal panel as defined in claim 1, characterized in that said groove in said fastening element bearing surface is generally V-shaped in cross section, including a generally axially extending cylindrical surface and a radially extending surface which extends from said surface at an acute angle toward said bearing surface, and said groove including ribs extending along said groove surface continuing along said radial surface defining generally enclosed pockets, said method including deforming said panel to substantially fill said V-shaped groove against the surface of said groove surrounding said ribs, thereby preventing relative rotation of said fastening element in said panel.

4. The method of attaching a fastening element to a metal panel as defined in claim 1, characterized in that said fastening element flange portion includes an axial opening opposite and coaxially aligned with said fastener portion, said method comprising locating said fastening element in an installation head having a plunger passage coaxially aligned with said panel opening and a plunger reciprocating in said plunger passage, said plunger having a locator pin and said method including locating said locator pin in said flange portion

opening prior to driving said bearing surface of said fastening element flange portion against said panel, said locator pin aligning said fastener element relative to said die member.

5. A self-clinching fastener element comprising a radial flange portion and a generally cylindrical axially projecting fastener portion, said flange portion including an annular bearing surface generally surrounding said fastener portion and said bearing surface including a generally annular groove extending axially into said flange portion adjacent to and surrounding said fastener portion, said axial groove being generally V-shaped in cross section, including a generally cylindrical axial surface defined by an exterior surface of said fastener portion and a radial surface extending from said axial surface toward said bearing surface at an acute angle, said axial groove further including a plurality of spaced ribs extending axially along said axial surface and continuing radially along said radial surface defining circumferentially spaced generally enclosed pockets.

6. The self-clinching fastening element defined in claim 5, characterized in that said fastening portion of said fastening element further includes a radial groove spaced axially from said annular groove.

7. The self-clinching fastening element defined in claim 5, characterized in that said radial surface of said annular groove includes a plurality of spaced enclosed pockets defined by said ribs.

8. The self-clinching fastener element defined in Claim 5, characterized in that said fastener element is a male element, wherein said flange portion comprises a radial head portion and said axially projecting fastener portion is an integral stud portion.

9. The self-clinching fastener element defined in Claim 8, wherein said male fastener portion is externally threaded to adjacent said generally annular groove in said head portion, but spaced from said head portion a distance equal to approximately the thickness of a panel to which said self-clinching fastener is to be attached.

10. The self-clinching fastener element defined in Claim 5, characterized in that said fastener element is a female fastener element, wherein said fastener portion comprises an annular barrel portion integral with said flange portion and said fastener element includes an axial bore therethrough generally coaxially aligned with the axis of said barrel portion.

11. The self-clinching fastener element defined in Claim 10, wherein said bore is internally threaded for receipt of a male fastener.

12. An element rivetable to a sheet metal part, consisting of a shaft portion and an integral head portion, characterized in that said element head portion includes on its underside a concave contact surface having peripherally closed pockets which are bounded partly by ribs extending radially outwardly from said shaft portion, with the ends of said ribs on said shaft portion extending in angled relief along said shaft portion having ends spaced radially from the head portion and said head portion having at least one depression spiraling around said shaft portion.

13. The element defined in Claim 12, characterized in that said shaft portion of said element has in the area of the relief ribs, as compared to the shaft portion away from the head portion, a larger diameter, at least one depression being contained in this area of the larger diameter.

14. The element defined in Claim 12, characterized in that said peripherally closed pockets have their greatest depth adjacent said shaft portion.

15. The element defined in Claim 12, characterized in that the area of said pockets, as compared to the contact surface of said head portion, are so selected that based upon the materials of the element and the sheet metal part in an optimum rotational lockout and noncritical surface pressure.

16. The element defined in Claim 12, characterized in that said closed pockets are bounded on their radially outer termination by a peripheral surface of said head portion.

17. The element defined in Claim 12, characterized in that said rib portions in the contact area of said head portion extend in a radial direction, flaring radially outwardly and extending without interruption into a radial peripheral surface of said contact area of said head portion.

18. The element defined in Claim 12, characterized in that the number of ribs ranges between six and eight.

19. The element defined in Claim 12, characterized in that said closed pockets, in plan view, are essentially quadratic.

20. The element defined in Claim 12, characterized in that the bottom surface of said closed fields are generally on a conical shell surface with an inscribed angle of generally 130 to 140°.

21. The element defined in Claim 12, characterized in that the side of the head portion away from the contact surface features a centering depression which is coaxial with the longitudinal axis of the element.

22. The element defined in Claim 12, characterized in that said element is in the form of a threaded bolt, wherein said shaft portion is externally threaded.

23. The element defined in Claim 12, characterized in that said one depression comprises the spiral thread groove adjacent said head portion.

24. The element defined in Claim 12, wherein said shaft portion has a smooth external cylindrical surface providing a bearing surface for receipt of a female bearing element.

25. The element according Claim 12, characterized in that said shaft portion includes a centering point having a conical end coincident with the longitudinal axis of said shaft portion.

26. The element according Claim 12, characterized in that said element is a self-attaching nut member, wherein said shaft portion is generally tubular having a bore coincident with the axis of said element extending through said element.

27. A self-riveting element and panel assembly comprising a plastically deformable metal panel having an opening therethrough, a fastening element including a radial head portion and a generally cylindrical axially projecting integral fastener portion, said head portion including an annular bearing surface adjacent said fastener portion and said bearing surface including a plurality of circumferentially spaced pockets and said fastener portion including a radial depression spaced from said head portion, said element fastener portion extending through said panel opening and said panel deformed into said pockets and said bearing surface of said head portion and radially into said depression in said fastener portion.

28. The element and panel assembly defined in Claim 27, characterized in that said panel includes an annular indented groove coaxially aligned with said pockets on the side of said panel opposite said element head portion.

29. The element and panel assembly defined in Claim 28, characterized in that said panel indented depression includes a wavy bottom surface.

30. The element and panel assembly defined in Claim 29, characterized in that said indented groove is interrupted.

31. A riveting die for attaching a self-riveting element to a plastically deformable metal panel, wherein said element includes a radial head portion and an axially projecting integral fastener portion, said head portion including a bearing surface adjacent said fastener portion having a plurality of circumferentially spaced pockets adjacent said fastener portion, said riveting die including an opening configured to receive said fastener portion of said element and an annular clinching portion surrounding said die opening and projecting from said die having a wavy end face including peaks and valleys extending in axial direction for deforming panel metal against said element bearing surface.

32. A method of forming a self-riveting element and plastically deformable metal panel assembly, said self-riveting element including a radial flange portion and an axially projecting integral fastener portion, said head portion including an annular bearing surface generally surrounding said fastener portion including a plurality of circumferentially spaced pockets adjacent said fastener portion and said fastener portion including a radial depression spaced from said head portion, said method comprising the following steps:

forming a hole in said metal panel configured to receive said fastener portion of said element;

inserting said fastener portion of said element in said panel hole; and

plastically deforming the material of said metal panel adjacent said panel hole to at least partially fill said pockets and said bearing surface of said head portion and substantially simultaneously deforming said panel adjacent said hole into said radial depression in said fastener portion.

33. The method of attaching an element to a panel as defined in Claim 32, wherein said panel is plastically deformed by a die member having an opening receiving said fastener portion and an annular clinching lip having a crown-shaped end portion including projecting spaced peaks separated by valleys, said method including driving said clinching lip into said panel metal and simultaneously rotating said element to locate said peaks opposite said pockets in said head portion.

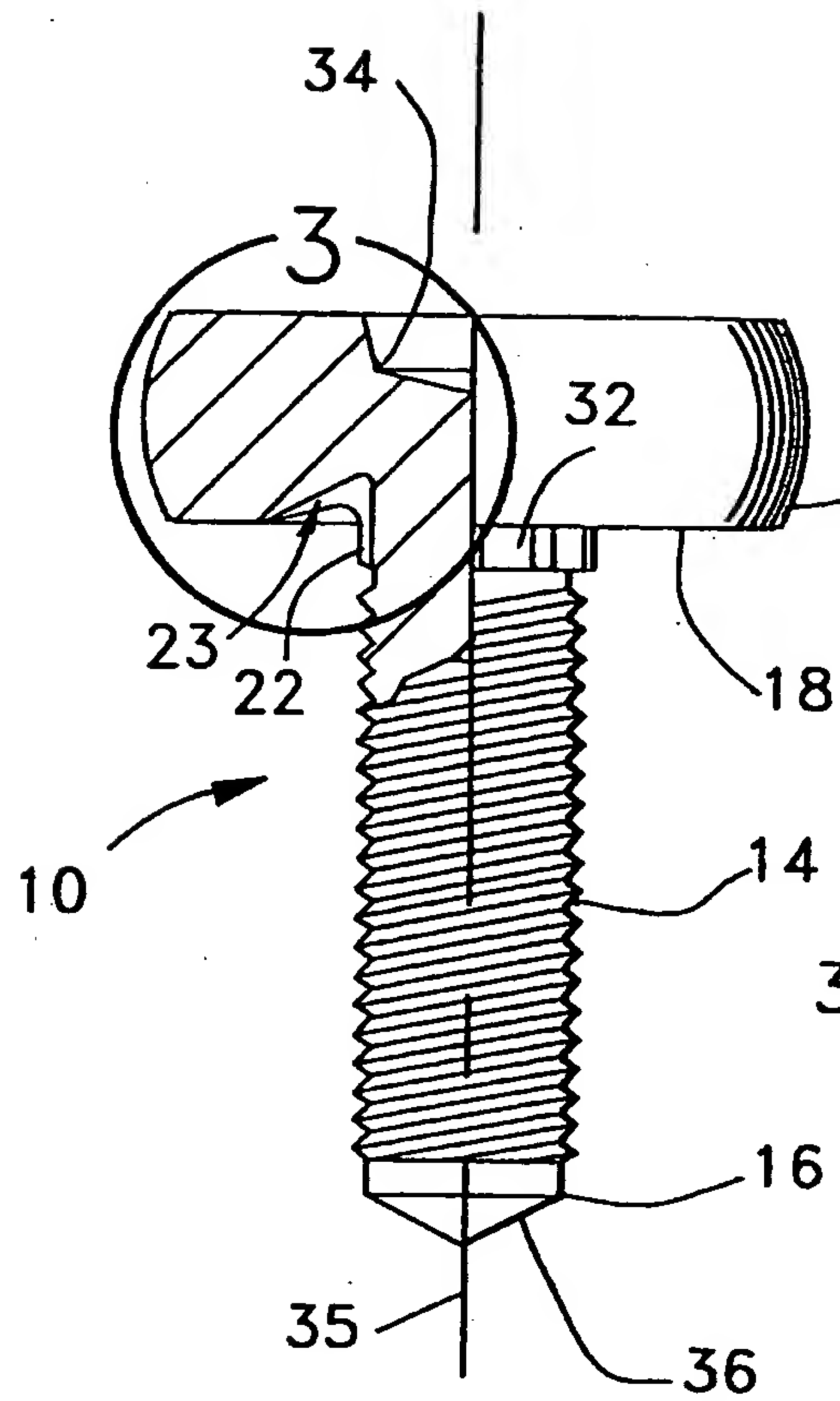

Fig-1

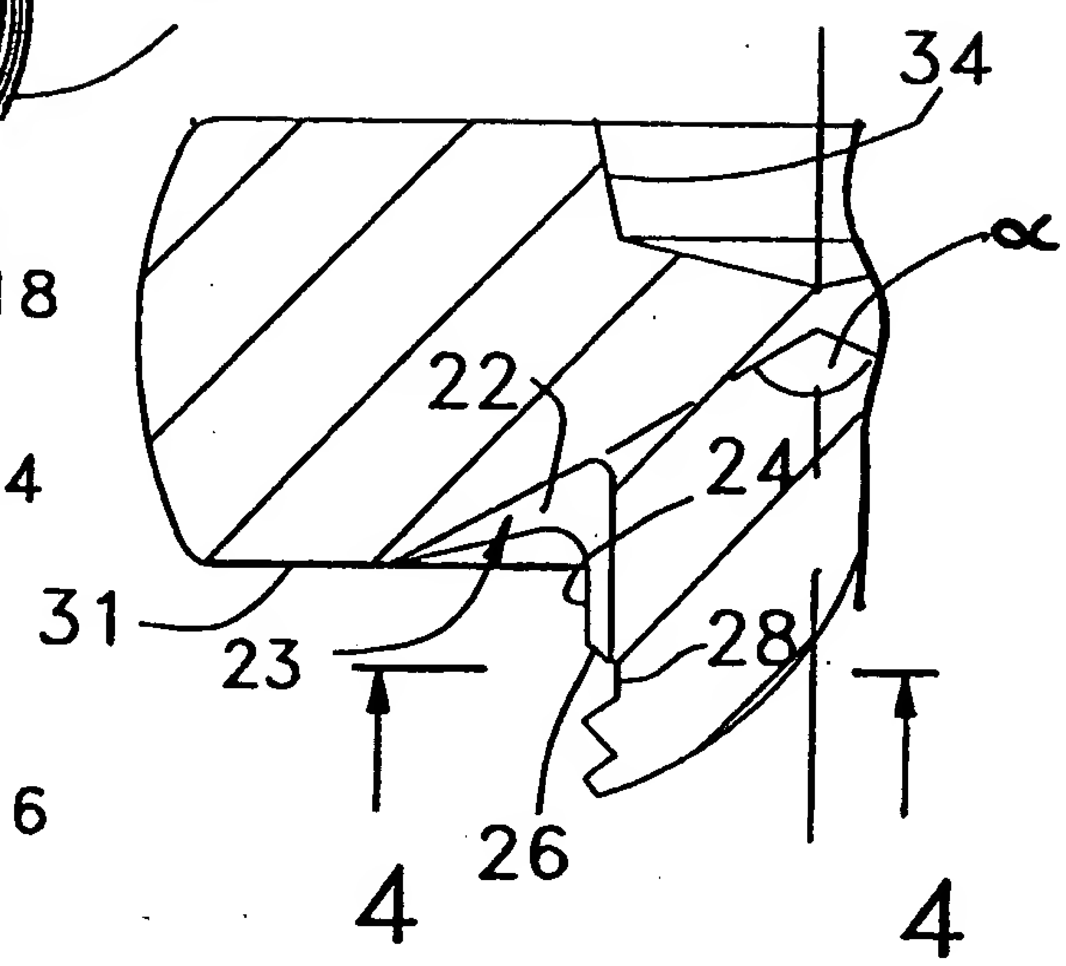

Fig-3

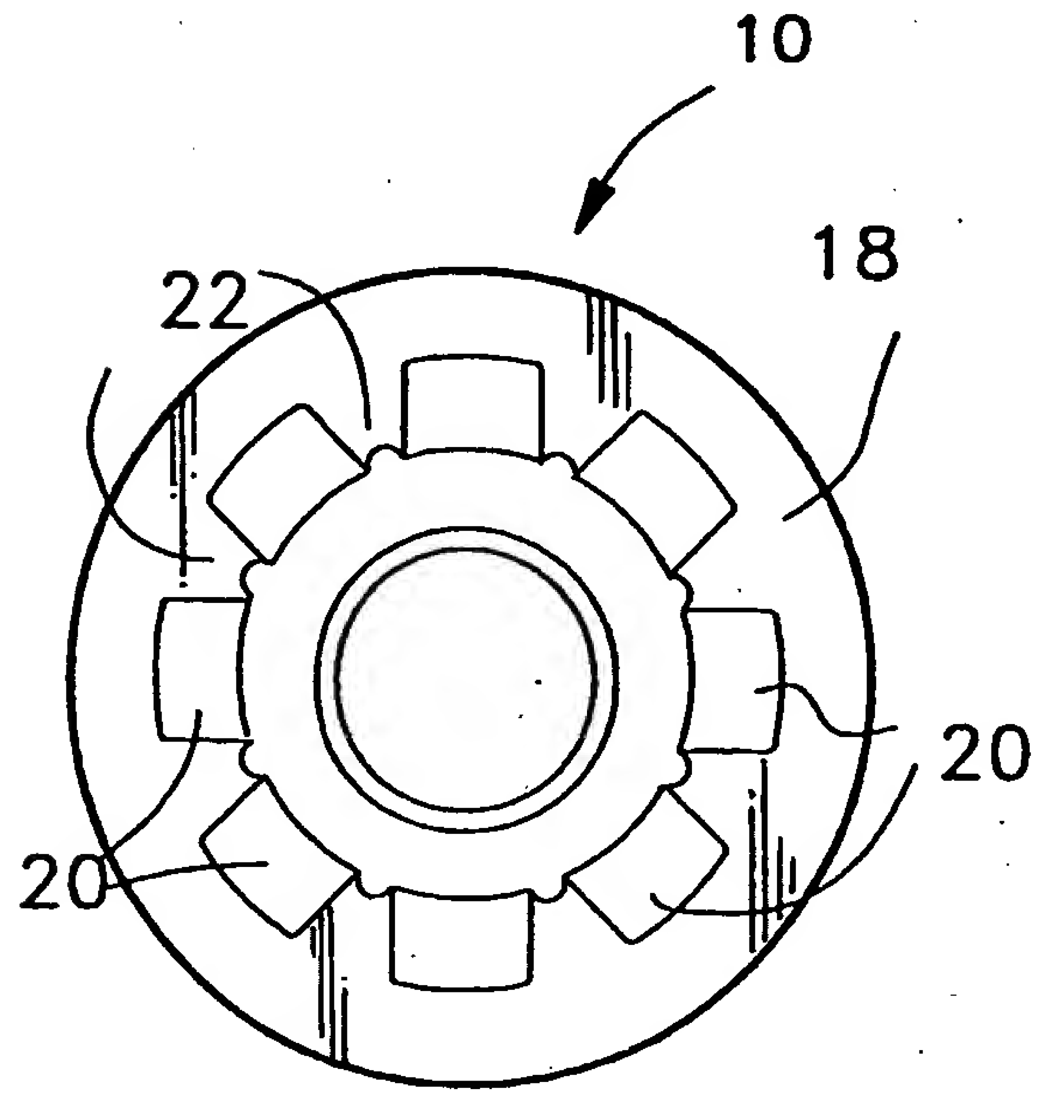

Fig-2

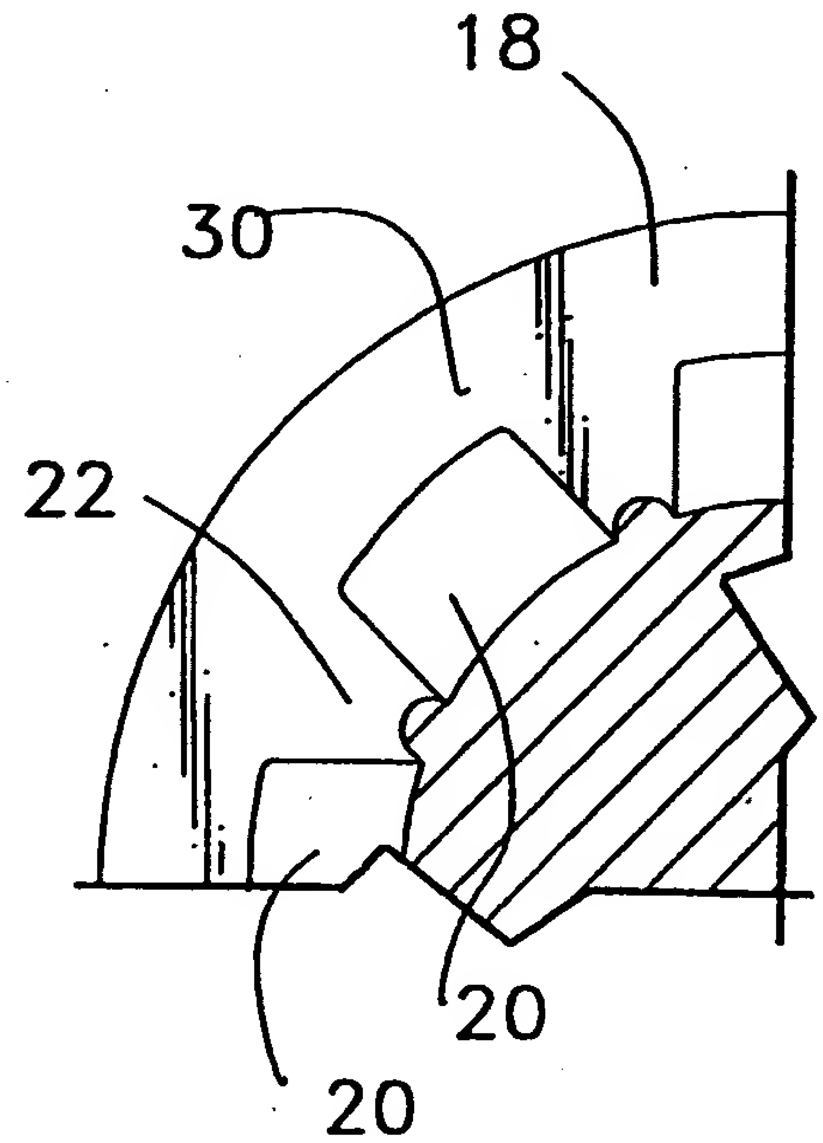

Fig-4

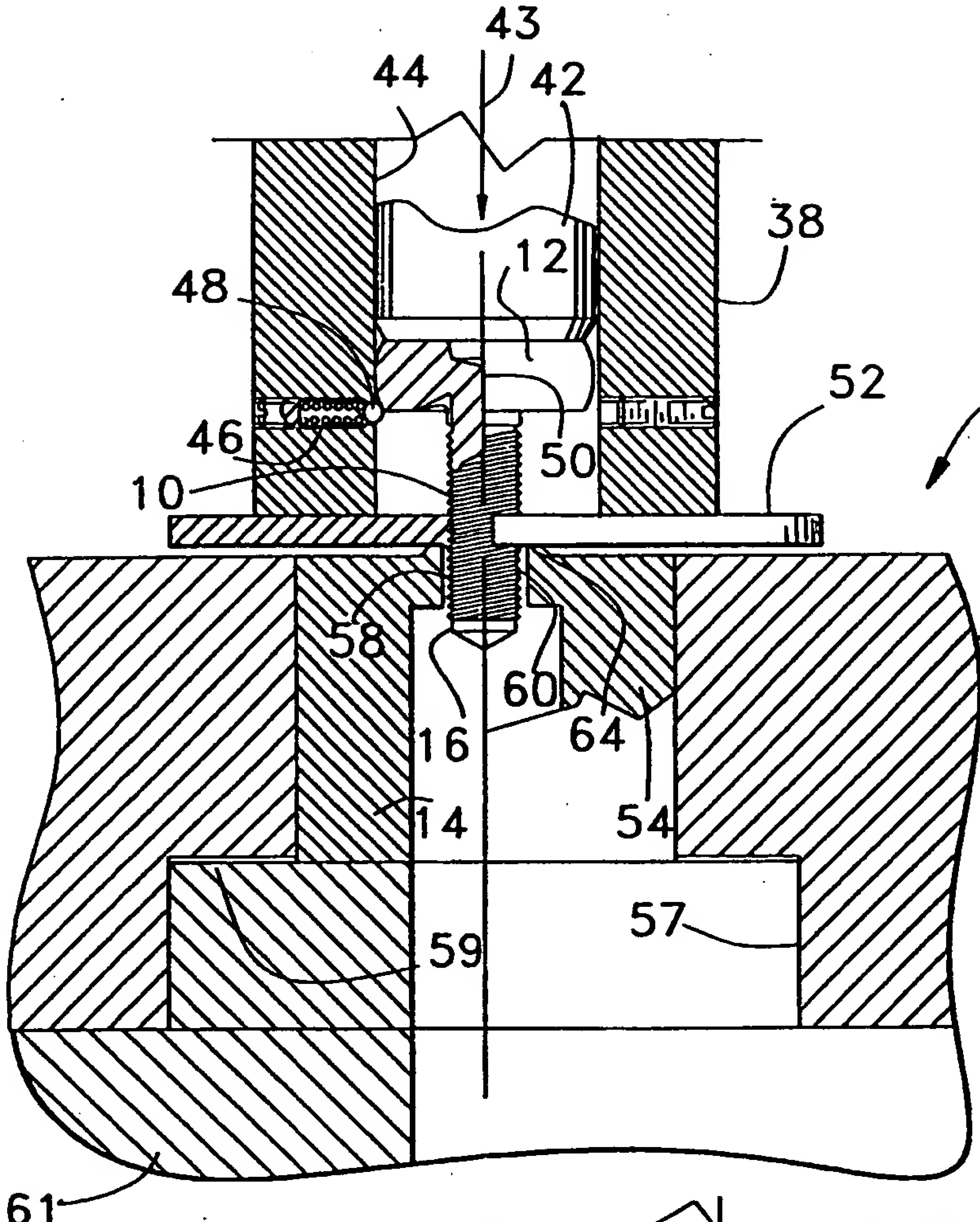
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Fig-5

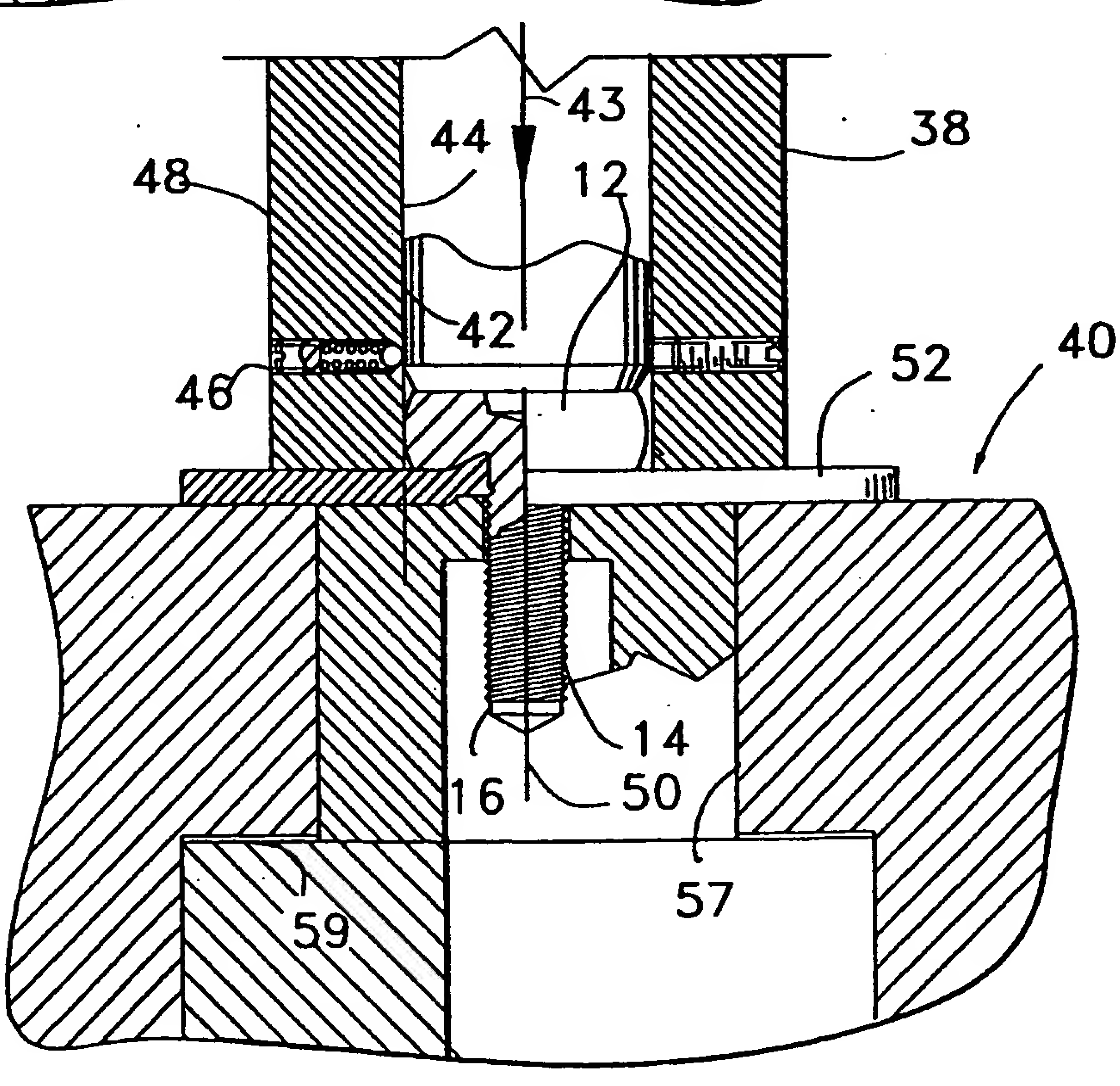
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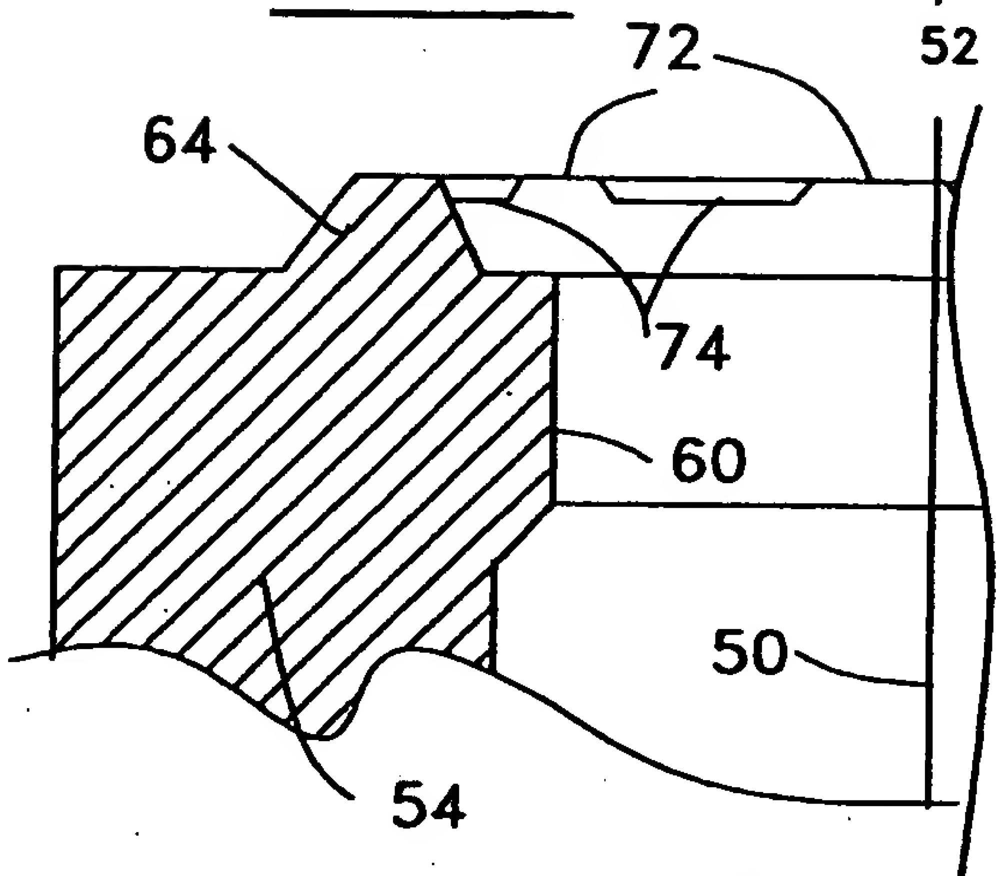
Fig-6

Fig-7



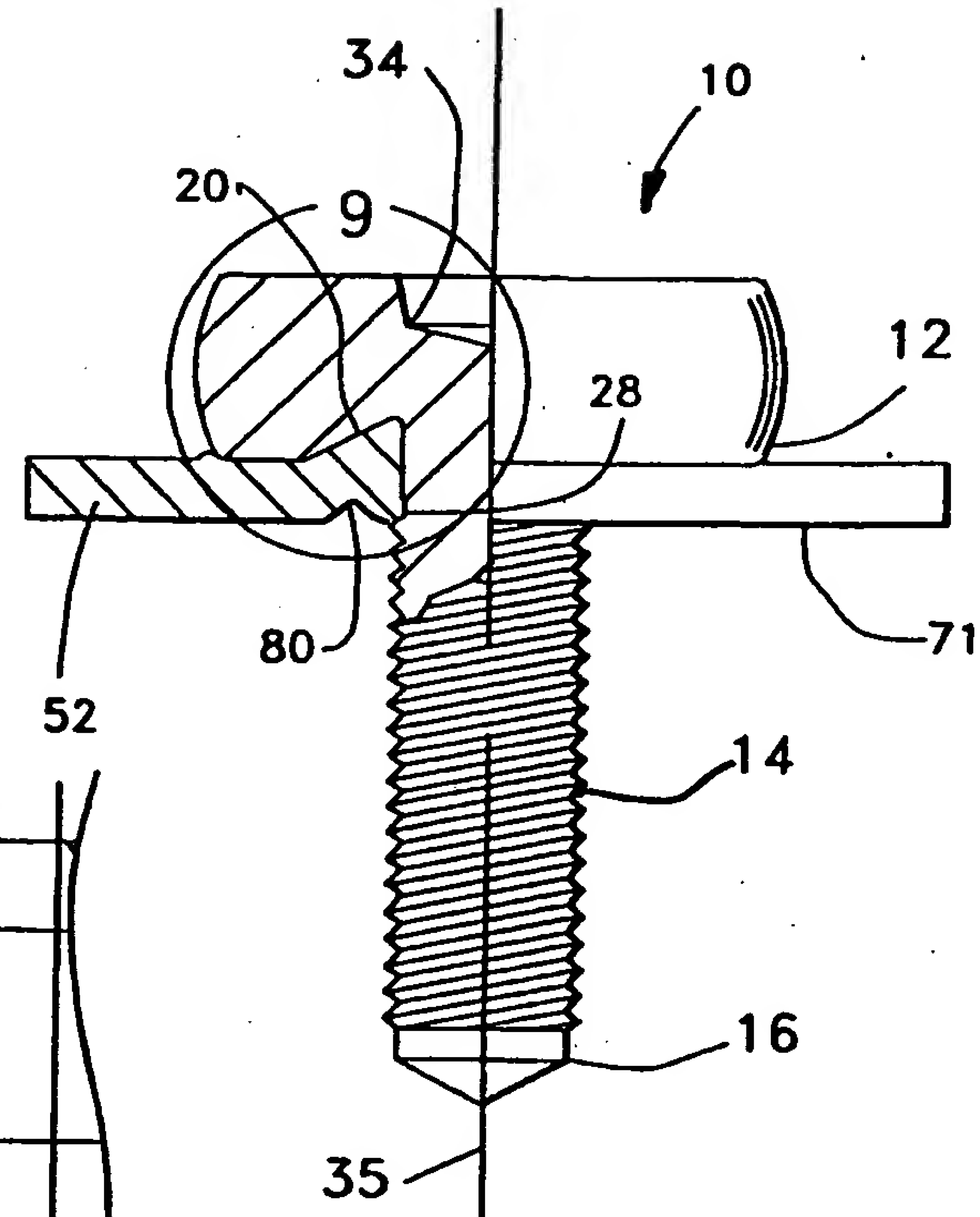
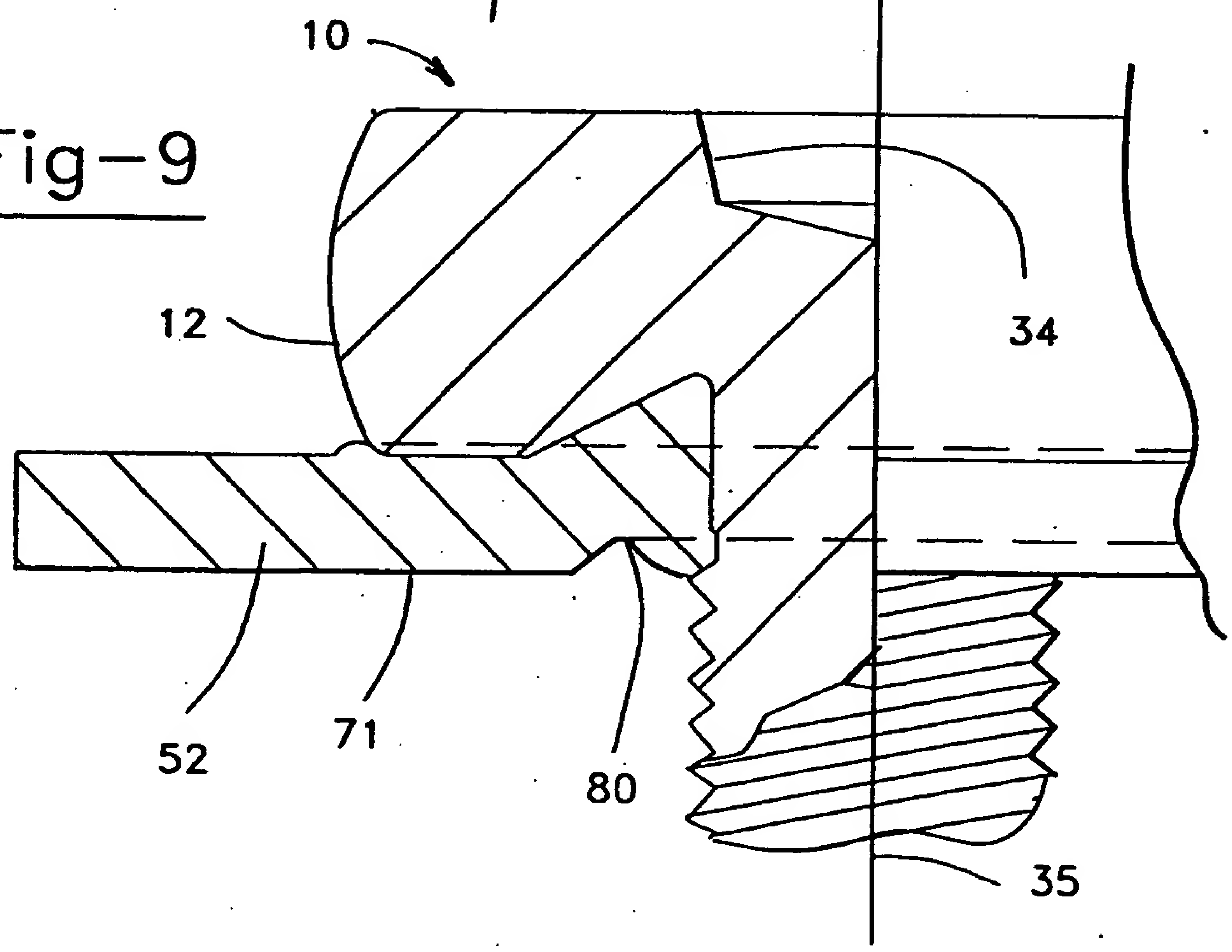


Fig-8

Fig-9



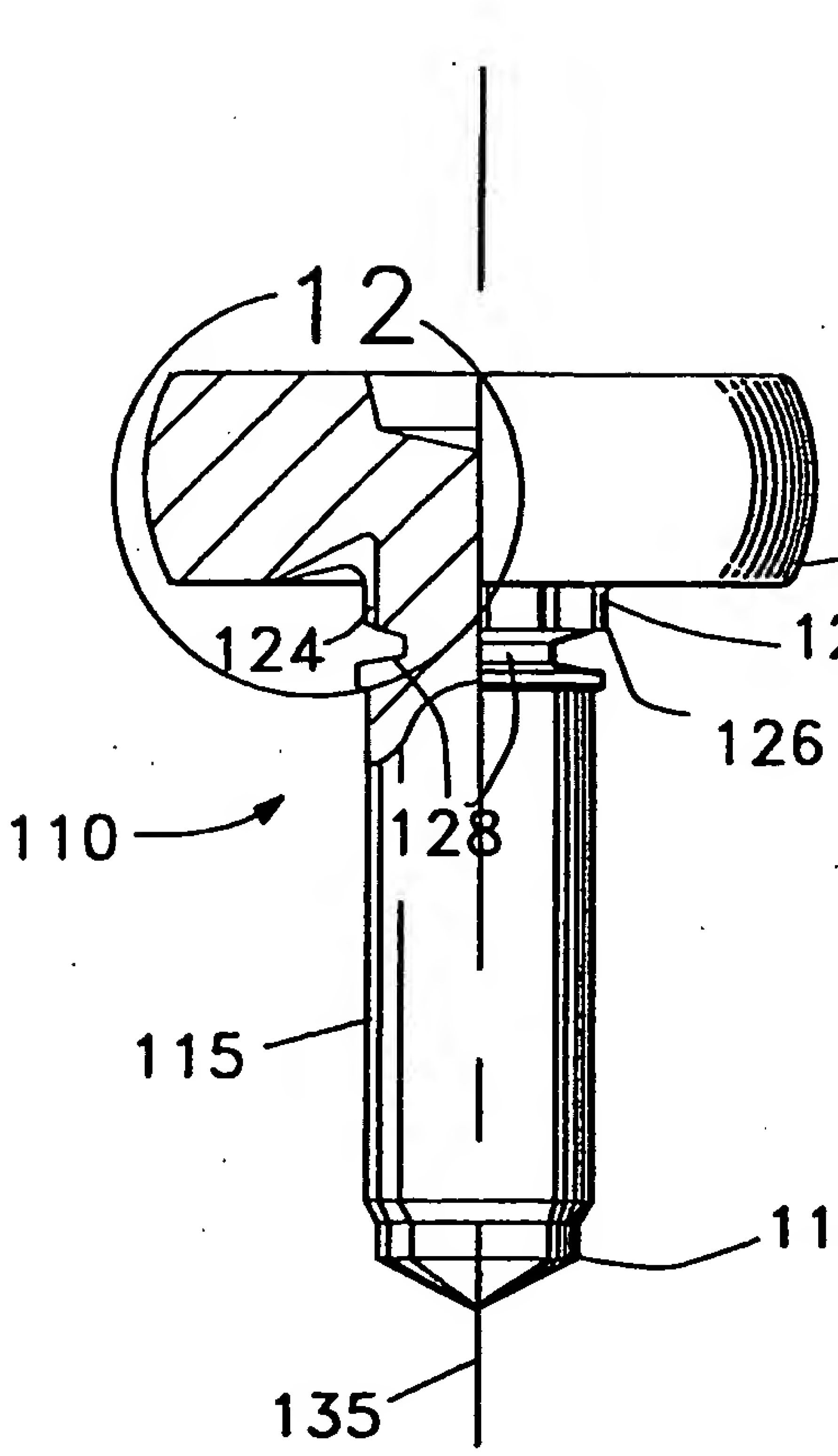


Fig-10

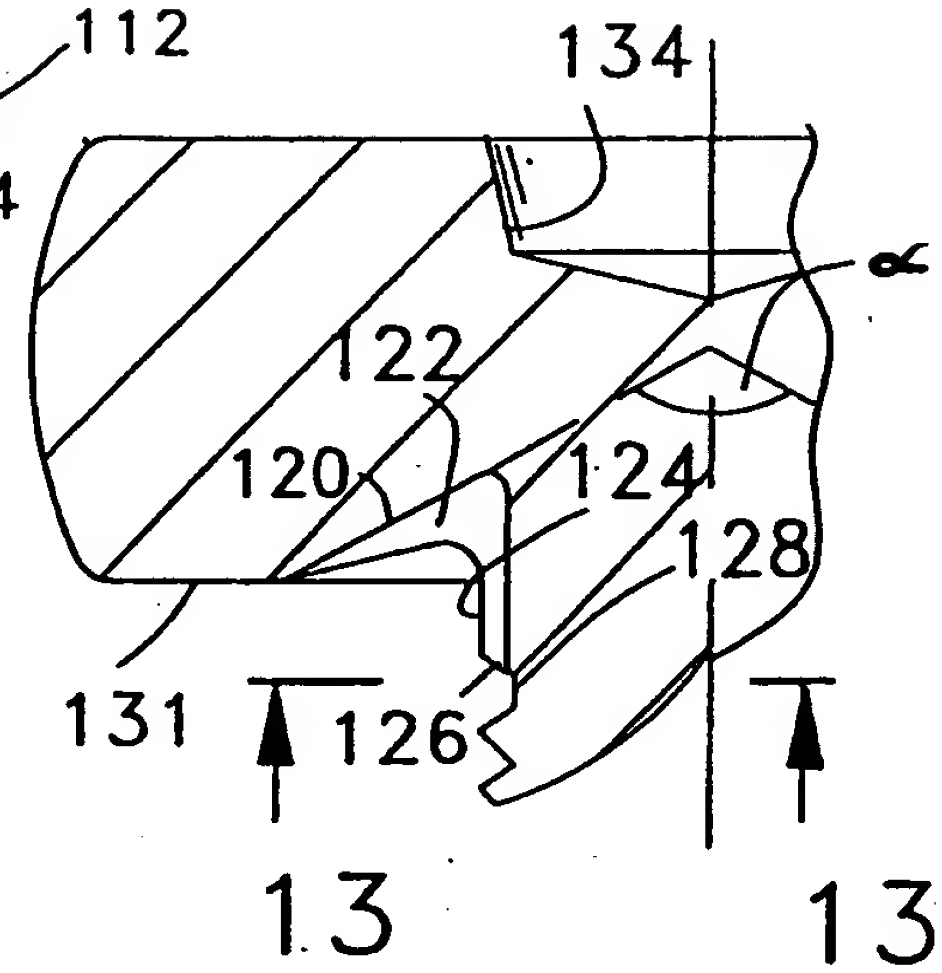


Fig-12

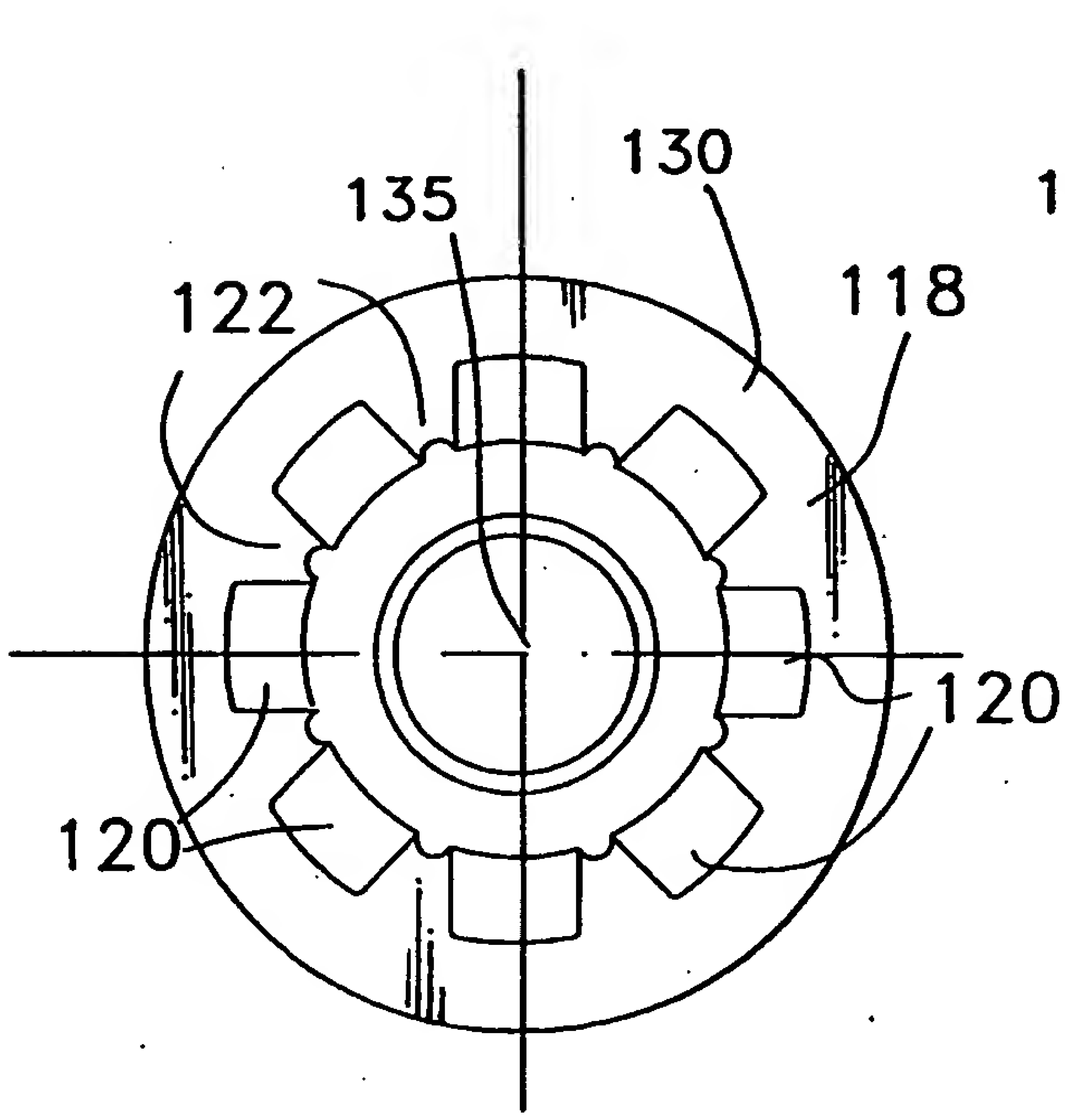


Fig-11

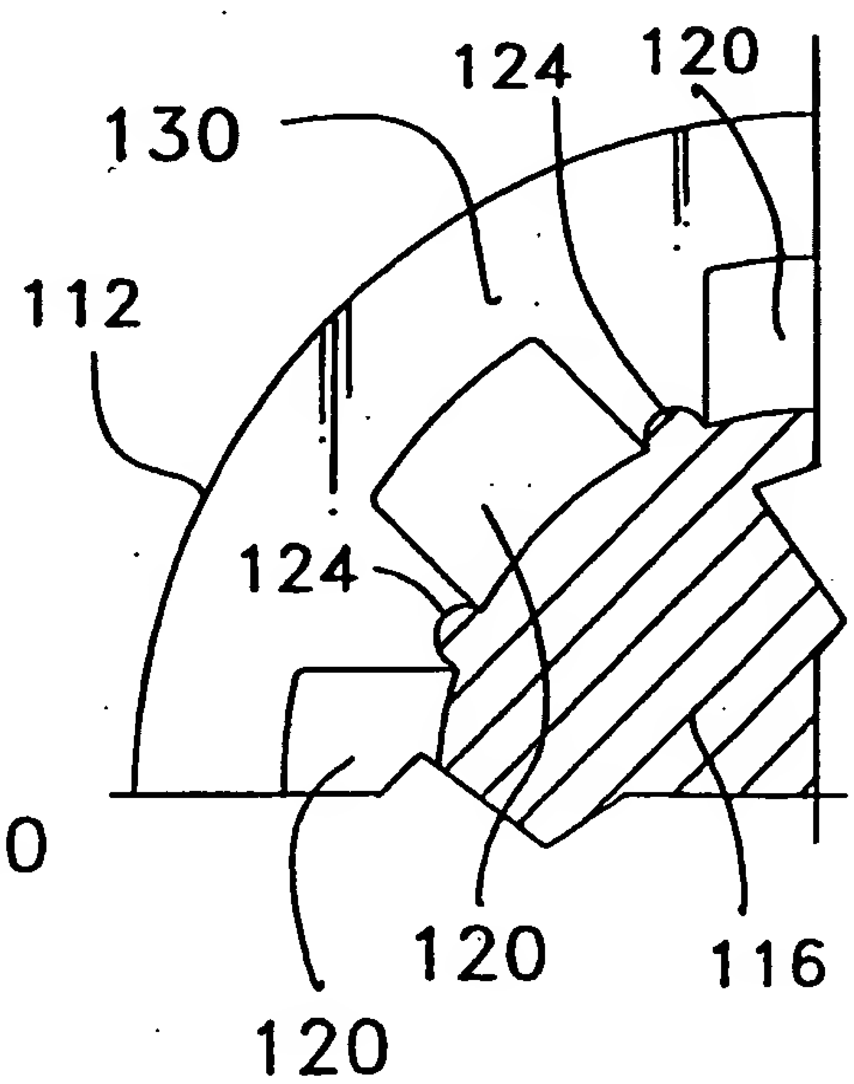


Fig-13

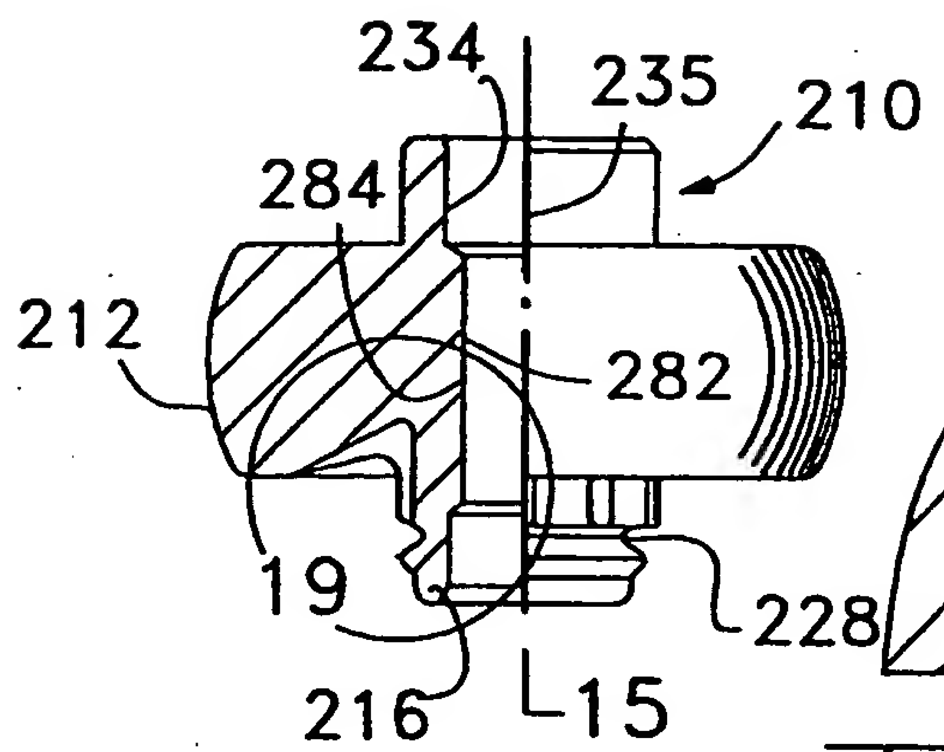


Fig-14

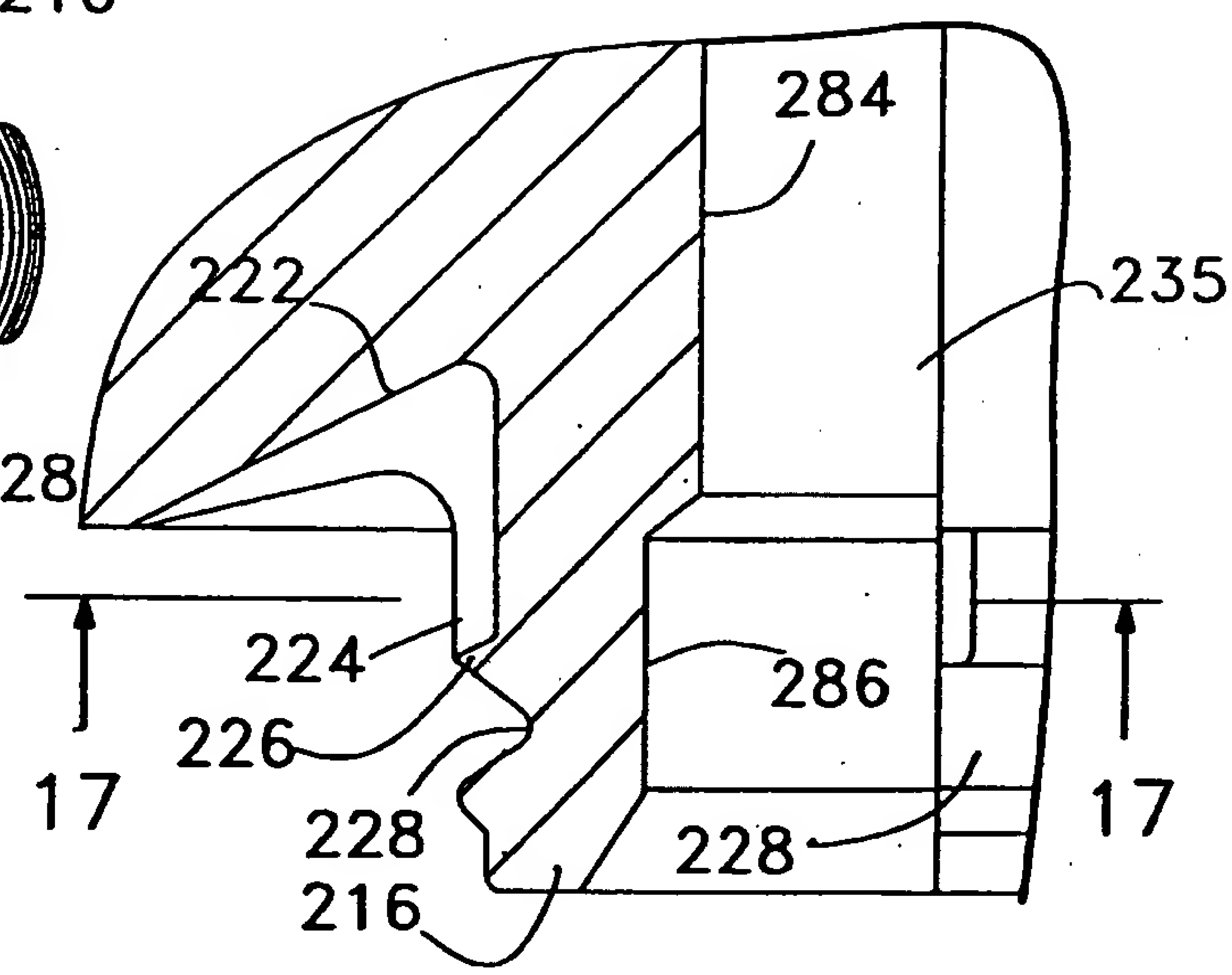


Fig-16

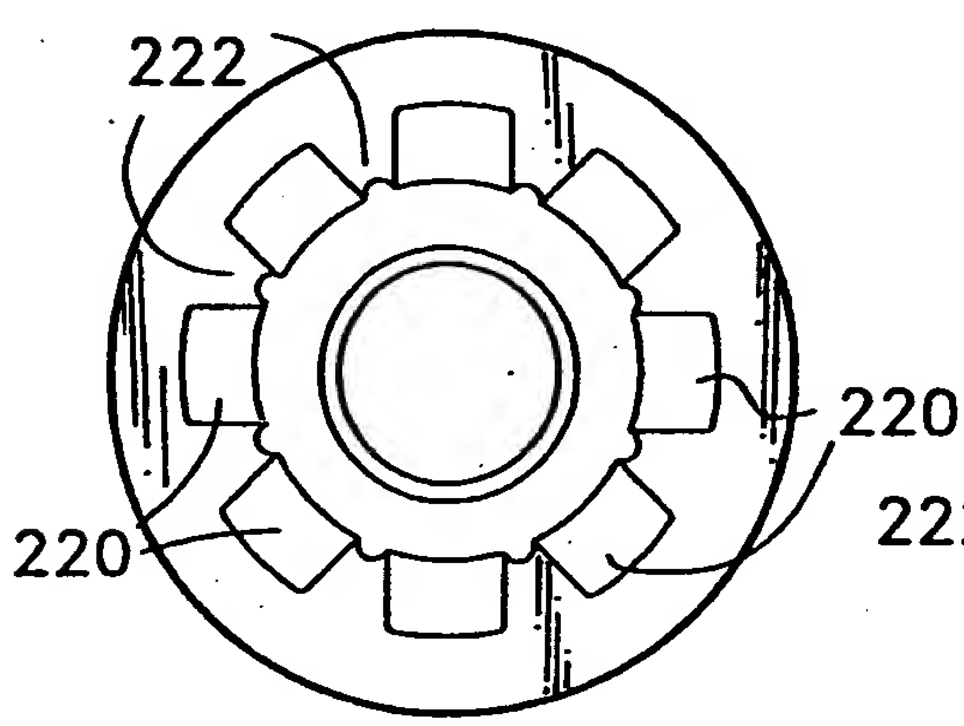


Fig-15

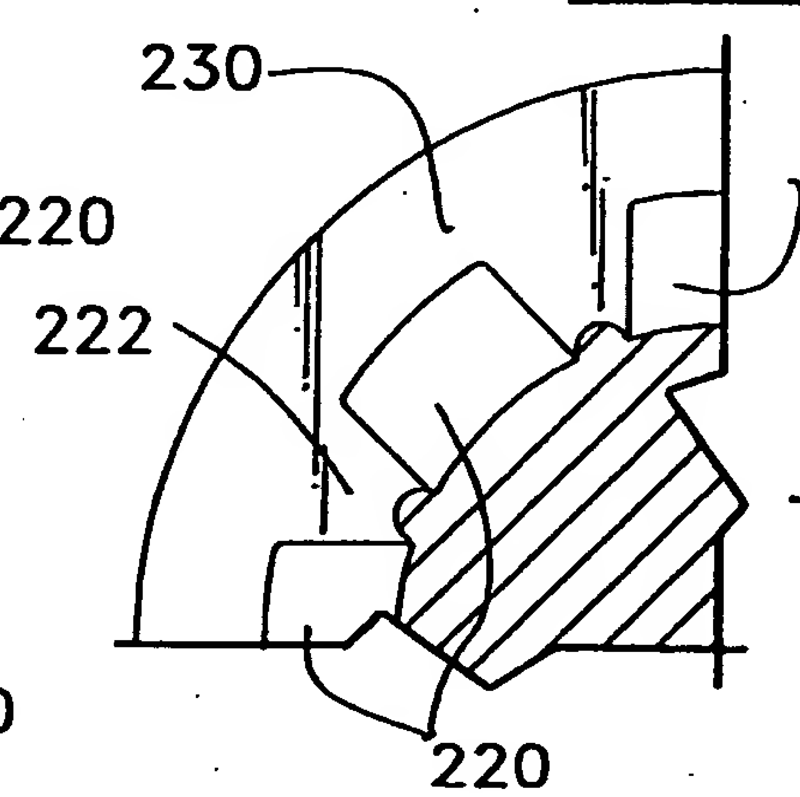


Fig-17

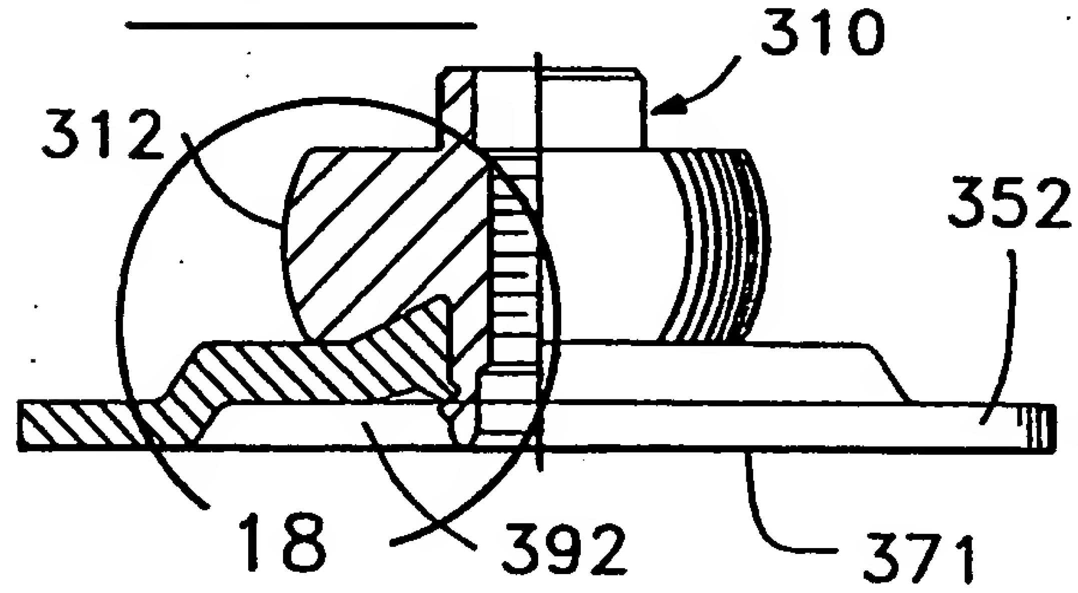


Fig-18

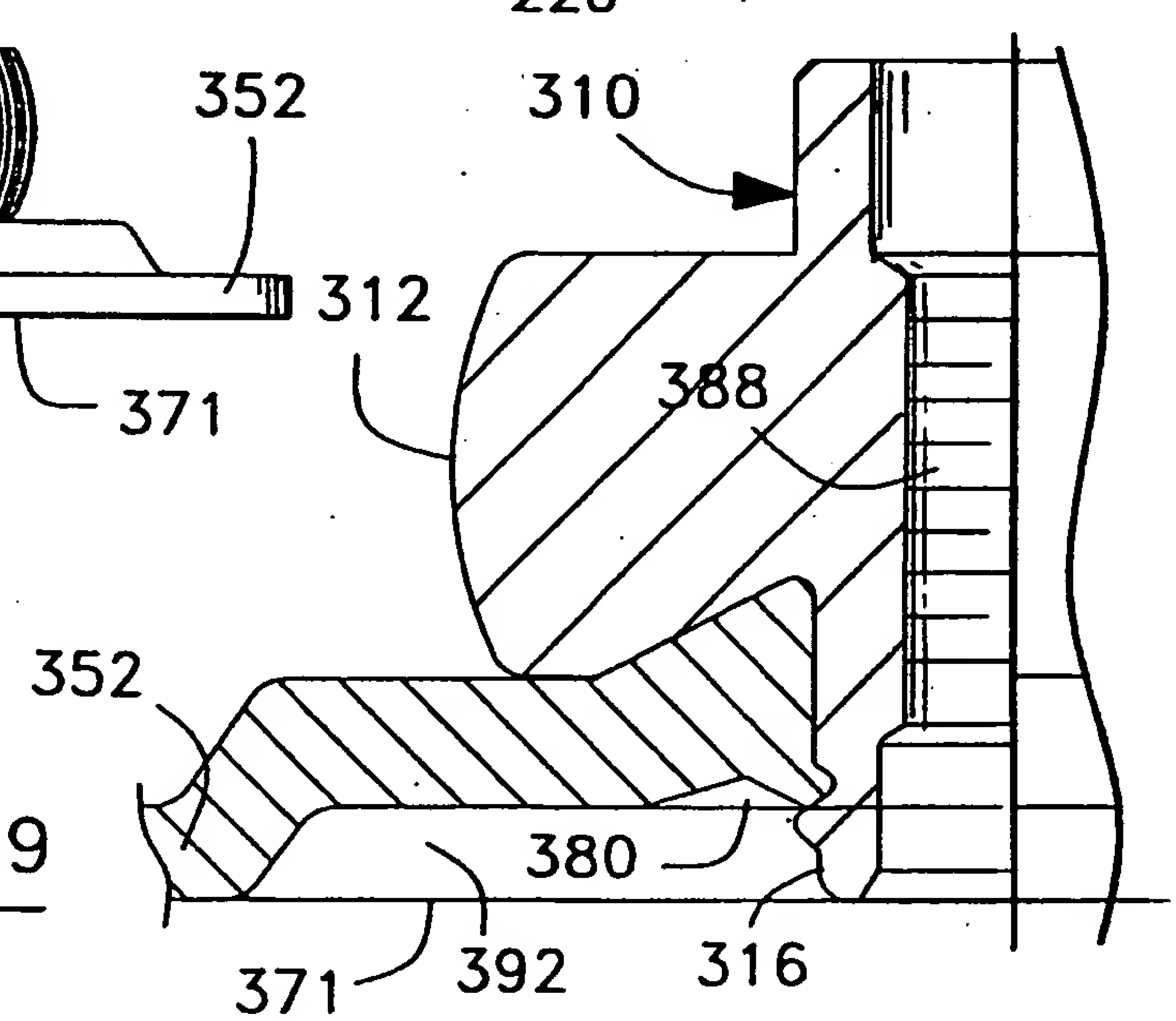


Fig-19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03507

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :Please See Extra Sheet.
US CL : 29/520,243.519; 411/184,188; 411/176,184,188,955
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 29/515,520,243.5,243.519; 411/176,184,188,955; 403/242,282

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,127,919 (SWANSTROM) 07 APRIL 1964.	1-33
A	US, A, 3,967,669 (EGNER) 06 JULY 1976.	1-33
A	US, A, 4,966,512 (TAKAKU) 30 OCTOBER 1990.	1-33
A	US, A, 3,770,037 (ERNEST) 06 NOVEMBER 1973.	1-33
A	US, A, 2,749,606 (DONAHUE) 12 JUNE 1956.	1-33
A	US, A, 2,177,191 (SANDBERG) 24 OCTOBER 1939.	1-33
A	US, A, 3,187,424 (DOUBLE ET AL.) 08 JUNE 1965.	1-33
A	US, A, 3,187,427 (DOUBLE) 08 JUNE 1965.	1-33

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
14 JUNE 1995

Date of mailing of the international search report
20 JUL 1995

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03507

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,337,946 (ANDERSON ET AL.) 29 AUGUST 1967.	1-33
A	US, A, 3,699,637 (ROSIEK) 24 OCTOBER 1972.	1-33
A	US, A, 3,878,598 (STEWARD) 22 APRIL 1975.	1-33
A	US, A, 5,251,370 (MULLER ET AL.) 12 OCTOBER 1993.	1-33
A	US, A, 3,820,579 (BARRY) 28 JUNE 1974.	1-33
A	US, A, 4,808,050 (LANDT) 28 FEBRUARY 1989.	1-33
A	US, A, 2,395,063 (PAULUS) 19 FEBRUARY 1946.	1-33
A	US, A, 4,543,023 (CAPUANO) 24 SEPTEMBER 1985.	1-33
A	US, A, 4,525,912 (KAZINO ET AL.) 02 JULY 1985.	1-33
A	US, A, 3,506,050 (POUCH ET AL.) 14 APRIL 1970.	1-33

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03507

A. CLASSIFICATION OF SUBJECT MATTER:
IPC (6):

B23P 11/00
F16B 39/282, 37/04